PROCTOR ENGINEERING GROUP

An Evaluation Of
UNITIL's Residential Space Heat Program

for program operations from October 1993 through September 1994

submitted by:
Michael Blasnik
Proctor Engineering Group
November 16, 1995

Introduction

Conservation Services Group (CSG) contracted with Proctor Engineering Group, a national research and evaluation company, to evaluate the savings of the Residential Space Heat Program that CSG operates for UNITIL Service Corporation's retail subsidiaries, Exeter and Hampton Electric Company, Concord Electric Company, and Fitchburg Gas and Electric Light Company. The Residential Space Heat Program was designed to capture the electricity conservation potential of residential units through direct installation of comprehensive electric-saving measures at no charge to the customer (except for attic ventilation if needed). The program targeted high-use electric space heat customers.

Program Description

The Residential Space Heat Program incorporates comprehensive, whole-building diagnostics and treatments to maximize the potential for energy-saving opportunities. During the period covered by this evaluation, the program provided participating households with the following energy-savings services and measures for applications which passed a cost-effectiveness criteria:

- comprehensive technical assessment and diagnostics of the house
- blower door assisted air sealing
- duct blaster™ assisted duct sealing of heat pump systems
- attic, basement and wall insulation upgrades
- hot water efficiency measures, including electric water heater wraps, pipe insulation, faucet aerators, and showerheads
- compact fluorescent light bulbs
- window improvements when only one glazing exists
- customer education on appliances and equipment operation

Overall, about 85% of participants received air sealing, 33% received insulation upgrades, 86% received one or more compact fluorescent bulbs, and about 40% received hot water measures.

Street
achusetts 02116
FAX: 617-236-7899

818 Fifth Avenue, Suite 208
San Rafael, California 94901
415-455-5700 FAX: 415-455-0229

Methodology

The modest size of the program dictated that the evaluation should remain fairly straightforward and inexpensive and rely upon existing data. A simple approach was used to weather normalize the usage data of participants and a matched comparison sample. The usage levels and changes in usage were summarized in several ways to assess program savings.

Data Set and Sample Selection

The program had 413 participants during the period of October 1993 through September 1994. Usage data were collected for the period of October 1992 through September of 1995 to provide for a full year of usage data before and after the participation period. Overall, 365 participants had complete billing history data available. A comparison group selection procedure was developed to identify a group of customers who did not participate in the program but were similar in other respects. This procedure proved to be quite complex involving a number of screens and stratification variables.

Winter and summer usage rates in the pre-program year were ranked on a scale of one to ten for all residential electric space heat customers (each rank corresponded to 10% of the customer base). Program recruitment was targeted to higher use customers based on these rankings and therefore the comparison group needed to have comparably high usage. To select a comparison group, the customer list was first screened to remove cases which were considered inappropriate because they:

- were identified as a business;
- were not considered a prospect for participation (e.g., had refused to participate);
- had incomplete billing histories;
- used less annual kWh than the lowest use participant;
- used more annual kWh than the highest use participant; or
- lived in a zip code which had no participants.

The participant group was then stratified so that a matching group of non-participants could be selected. The stratification variables were :

- retail affiliate;
- single vs. multi-family;
- winter usage ranking; and
- summer usage ranking (to facilitate matching, the ten categories were combined into three).

A total of 61 unique combinations of these factors were identified in the participant group. For each of these combinations (i.e., for each strata cell), comparison group customers were selected randomly to match the total number of participants in the same cell. To provide a better geographic component to the selection process, the odds of selecting each non-participant in a cell were proportional to the number of participants with the same first three zip code digits. Overall, this process resulted in a comparison group of 356 non-participants (nine slots could not be filled due to an insufficient number of matching non-participants).

Weather Normalization

The usage data were analyzed to adjust for differences in heating degree days between the pre and post treatment years. A simple approach was employed to disaggregate each year's consumption for each house into "baseload" and heating components. Baseload usage was estimated as the average of the three lowest months of usage. This baseload level was subtracted from the usage during the winter months to estimate the raw heating usage. The raw heating usage was then multiplied by the ratio of typical weather year heating degree days to actual heating degree days (base 65°F) in order to estimate normalized heating usage. The normalized total consumption was then calculated as the sum of the normalized heating usage plus the total non-heating usage. The same procedure was applied to all participant and comparison group households.

Data Screening

The region served by the program has a large percentage of households which use supplementary heating sources, particularly wood stoves (48% of participants have supplementary heat). The presence of supplemental heating complicates the analysis because large changes in usage may occur which are due to changes in supplemental heat usage unrelated to the program. These large usage changes can overwhelm program effects and add tremendous variability into the data. To avoid such problems and provide more reliable savings estimates, households were removed from the analysis if they experienced a change in normalized usage of more than 40%[1]. This screen may be considered somewhat conservative because it could remove some participant households who experienced large savings due to the program. The screen removed a total of 41 participants and 52 non-participants from the analysis, leaving final samples of 324 participants and 304 comparison group households. The resulting samples should be considered representative of the majority of households with reasonably stable usage patterns, not the entire population.

Results

The results of the normalization process were used to calculate average usage and savings levels for the participant and comparison groups. Net savings were calculated as the difference in average savings between the participant and the comparison groups. Standard t-tests were used to calculate 90% confidence intervals. The results of this analysis are summarized in Table 1 on the next page.

---

[1] The September 1995 evaluation of a small group of early participants used more extensive screening criteria because of the smaller sample size and less sophisticated comparison group selection process.

Table 1. Analysis Results: Mean Usage and Savings Levels all values in kWh/yr unless otherwise noted			
	Participant Group (n=324)	Comparison Group (n=304)	Net Savings
Pre-Program Normalized Usage (kWh/yr)	19,687	19,637	
Post-Program Normalized Usage	18,151	19,250	
Annual Savings	1,536	386	1,150
Savings %	7.8%	2.0%	5.8%
± 90% Confidence interval	±265	±293	±394
Savings - Houses Receiving Insulation (113)	2314		1928
Savings %	10.9%		9.1%
± 90% Confidence interval	±476		±561
Savings - Houses Not Receiving Insulation (211)	1119		733
Savings %	5.9%		3.9%
± 90% Confidence interval	± 310		± 436

The average savings for participants was 1536 kWh/yr while comparison group households experienced average savings of 386 kWh/yr, yielding a net savings of 1150 kWh/yr. Houses receiving insulation had more than double the savings of houses which did not. All of these savings were highly statistically significant. The prior impact evaluation of early participants in this program found similar changes in participant usage but a slight increase in comparison group usage, yielding considerably higher overall net savings of 1740 kWh/yr (2561 kWh/yr for insulated and 852 kWh/yr for not-insulated). It is not entirely clear whether the savings have remained the same from program measures but non-participants are also saving due to other factors, or whether savings from the measures are lower than before. PEG explored this issue and discovered several reasons why the results may differ from before.

The program started out targeting high use customers who had participated in an earlier program which was targeted at water heating savings. Compared to later participants, these customers had higher pre-program usage rates (21,502 kWh/yr on average), were more likely to receive insulation (50% vs. 33%), were less likely to receive water heating and lighting measures, and were more likely to live in single family homes. This combination of changes would be expected to lead to somewhat lower savings from insulation (due to the lower prior usage rate), higher savings in the group not receiving insulation, and lower savings overall due the lower frequency of insulation measures. These changes are consistent with the results.

Although the reduction in program savings was somewhat expected, the apparent savings in the comparison group is still a concern because of the difficulty in ensuring a truly comparable group and the high proportion of customers with large changes in usage (15% were screened out for usage changes of more than 40% and 21% of the remaining cases had usage changes of more than 20%). The average "savings" from this group may not be representative of what would have happened to participants' usage in the absence of the program. In addition, the simple weather normalization approach used may be responsible for some of the apparent savings among both participants and non-participants[2].

[2] The weather normalization process may be responsible for some of the gross "savings" because it is based on a 65°F base, which is considered high for electrically heated homes. When the analysis was repeated using base 58°F, the comparison group savings dropped to just 47 kWh/yr with similar changes in the participant group.

After examining all of these issues, PEG concludes that the net savings estimates provide a reasonable basis for assessing program performance, but the uncertainty in the comparison group adjustment needs to be considered when interpreting the results.

Additional Analyses

Several additional analyses were performed to provide further insight into the program impacts and the evaluation methods.

Retail Affiliate & Housing Type Savings: The savings results were analyzed by retail affiliate and by housing type (single vs. multi-family). There were no statistically significant differences in savings for any retail affiliate, although customers of Exeter and Hampton Electric had the highest average net savings (1244 kWh/yr) while those of Fitchburg Gas and Electric Light had the lowest (638 kWh/yr in a small sample of only 18 participants). A larger sample of Fitchburg customers would be needed to determine if these lower savings are due to chance or represent a real pattern. A comparison of multi- and single family customers found higher savings in the single family homes (net savings of 1308 kWh/yr vs. 278 kWh/yr for multi-family customers). The low net savings in multi-family buildings may be suspect because they were significantly affected by a large comparison group savings of 597 kWh/yr. Better comparison group selection procedures, such as matching on number of units, may lead to different results.

Median Analysis: The overall savings analysis was also performed using medians instead of means to ensure that the figures reported are not unduly influenced by outliers. This analysis found comparable net savings (1085 kWh/yr overall, 1810 for insulated and 782 for not insulated).

Comparisons to Predicted Savings: The relationship between savings measured by the billing analysis and those predicted from engineering algorithms was explored using two approaches: ratio estimation and an SAE-type multiple regression model. The ratio estimate was calculated by dividing the average measured savings by the average predicted savings. For the 313 participants with savings predictions available, the average savings were 84% of predicted. If adjusted for comparison group savings, this ratio drops to 64%. The SAE model involves statistically fitting a relationship between usage rates before and after the program and predicted savings. This analysis indicated that 47% of predicted savings were realized by the program. This low realization rate is due to the substantial variability in usage rates, leading to a combination of some participants with low predicted savings achieving high apparent savings, and some participants with high predicted savings showing little savings. Therefore, while measured savings did not track predictions very closely, the ratio estimates show that average measured savings were a significant proportion of those predicted. A review of savings predictions, potentially more stringent data quality screening, and the use of more sophisticated usage analysis may lead to more consistent results between the methods.

PRISM Analysis: As a test for future evaluations, the usage data were also analyzed using the PRInceton Scorekeeping Method (PRISM). PRISM provides a more accurate and flexible tool for weather normalization by using regression modeling of the relationship between weather and usage and estimating site-specific balance points. PRISM also provides statistical assessments of the reliability of the results for each house. The PRISM analysis for the houses reported on in table 1 showed somewhat higher net savings of 1303 kWh/yr overall, with net savings of 2039

kWh/yr for the insulated houses and 909 kWh/yr for those not insulated. These results are preliminary because the full array of data input and output screening and analysis normally employed in using PRISM was not been performed. PRISM has the added advantage that it can produce fairly reliable savings estimates using less than a year of data. PEG recommends using PRISM for future evaluations because of its inherent advantages and general acceptance in the evaluation community.

Conclusions

Overall, the Residential Space Heat Program achieved significant savings for its participants that compares reasonably well to similar programs operating in the region. Households which received insulation averaged more than 1900 kWh/yr in savings. Households which did not receive insulation averaged about 700 kWh/yr savings. The average savings were higher in single family houses than multifamily buildings.

The prevalence of supplemental heating sources caused the analysis to focus on households with reasonably stable usage patterns. Still, many customers included in the analysis experienced large changes in usage unrelated to the program. The net effect of these changes was an average decline in comparison group usage which reduced the estimate of net participant savings. A more detailed assessment of the comparison group and the use of more sophisticated weather normalization techniques (e.g., PRISM) may be worth pursuing for future evaluations.